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Evaluating collaborative features of critical care systems: A methodological study of information technology in surgical intensive care units

Madhu C. Reddy [a,*], M. Michael Shabot [b], Erin Bradner [c]

[a] College of Information Sciences and Technology, The Pennsylvania State University, 321J IST Building, University Park, PA 16802-6823, USA
[b] Memorial Hermann Healthcare System, Houston, TX and Cedars-Sinai Medical Center, Los Angeles, CA, USA
[c] Autodesk, Inc., San Rafael, CA, USA

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Abstract

Purpose. This study evaluates the collaborative features of a critical care system, CV, used in a surgical intensive care unit (SICU). In the evaluation, we take a *socio-technical* perspective—a view that the technical features of the system and social features of the work are fundamentally interrelated.

Methods. We utilized qualitative data collection and analysis methods. We undertook seven months of observations and conducted more than thirty interviews of healthcare providers in the SICU.

Results. We found that there are a wide variety of collaborative activities such as morning rounds and medication administration that a critical care system must support. We further found that CV supports healthcare providers by providing them awareness of others' activities.

Discussion. We discuss the issue of awareness in greater detail. We also provide some recommendations on how to evaluate how well a system supports collaborative features such as multiple perspectives on information, workflow dependences, and context.
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1. Introduction

Critical care systems are complex and often expensive to develop but are crucial to providing effective care to patients in settings such as intensive care units and emergency departments. A key feature of these settings is the collaborative nature of the work. In particular, intensive care units (ICUs) are information-rich, complex, and highly collaborative critical care environments. Baggs and associates [1,2] found that poor collaboration between physicians and nurses in an ICU setting resulted in poor patient outcomes. Similarly, researchers have pointed out the importance of collaboration in intensive care units during information retrieval and use activities [3]. Although many critical care systems are developed with a focus on the individual user, these same systems are often utilized to support collaboration [4,5]. For instance, the electronic medical record (EMR) is viewed by most people as a repository for patient information accessed by individual health care providers. While it does serve as a patient information repository, the EMR also helps support collaboration amongst patient care team members by providing them with information about what other team members have done for the patient [6]. Clinical systems such as an EMR or a computerized physician order entry (CPOE) mediate

* Corresponding author. Fax: +1 814 865 6426.
E-mail address: mreddy@ist.psu.edu (M.C. Reddy).

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far more collaborative activities than originally anticipated by their designers.

Although collaboration is an important aspect of critical care and, as just described, systems need to support this collaboration, most evaluations of critical care systems focus on how well they support the *individual* user; for instance, focusing on the suitability and effectiveness of the user interface for single-user interaction [7]. With a few exceptions [3,5,8], evaluating how well these systems support collaboration is often ignored. For critical care systems, we must not only evaluate how well they store and present information but also how well they support the collaborative features of team members' work; failure to do so can adversely impact patient care. For instance, Ash et al. [9] report many instances in which patient care information systems seem to foster errors rather than the intended goal of reducing errors. Furthermore, researchers continue to report the confounding impact of computerized systems in healthcare. Estellat et al. [10] report that 49% of potential prescribing errors observed in their study of a computerized physician order entry system were the result of the use of the system itself (e.g. unit error or prescription inconsistency).

Therefore, we must utilize approaches to evaluating critical care systems that do not just focus on examining how they support individual users. One approach is to take a *socio-technical* perspective—a view that the technical features of the system and social features of the work are fundamentally interrelated—when evaluating critical care systems. By taking this perspective during the evaluation process, we can focus not only on how well the system supports individual users but also how well the system "fits" in the environment and supports collaboration. To examine how well a critical care system can support collaborative care, we evaluated an EMR system used in a surgical intensive care unit of a large, urban teaching hospital. We conducted this evaluation using data collection and analysis methods that allowed us to focus on the system from a socio-technical perspective.

One of the main goals of our study was to evaluate how well a critical care system such as an electronic patient record supports collaboration amongst patient care team members in a busy and information-intensive environment of a surgical intensive care unit. Therefore, in this paper, we discuss how to evaluate collaborative features of critical care systems and illustrate how a critical care system such as an EMR can support collaborative work activities. In the next section, we discuss the methods and focus of critical care systems' evaluation. Section 3 describes an evaluation of an electronic medical record used in a surgical intensive care unit. In Section 4, we discuss collaborative features of work that these systems must support. We also discuss a particular approach for evaluating how well critical care systems support collaboration. Finally, we conclude with some thoughts on collaboration and critical care systems.

2. Background

Medical informatics researchers have used a wide variety of techniques and methods for evaluating information systems. These evaluation methods include *qualitative* techniques such as observations and interviews [11–13] and *quantitative* techniques such as surveys [14,15]. The suitable evaluation technique depends on the nature and scope of the particular study. For instance, a variety of medical informatics studies using quantitative methods have highlighted various important issues dealing with evaluation such as acceptance [14], usability [16], and outcomes [17]. Although quantitative techniques have provided important insights into information systems, our experiences as well as others [4,18] have shown that qualitative methods provide some of the best approaches to trying to answer the "how" and "why" questions of evaluation studies [19]. These questions bring to the forefront the important role that information systems play in supporting collaboration by focusing on the socio-technical aspects of the system. For instance, the question "how can an information system make team collaboration more effective?" is difficult to answer without examining the different ways that team members collaborate with each other and the type of work activities that require collaboration. Qualitative techniques allow researchers to try to answer these questions in greater detail.

2.1. Evaluating collaborative features

Evaluating collaborative features of a system requires focusing not only on the technology but also on the environment in which the technology is being implanted. Currently, many evaluation methods focus on the individual user's interaction with the technology. However, these methods do not examine how well the technology is incorporated into the daily work of the organization. Therefore, when evaluating a system, both the technical and organizational issues need to be viewed together. This type of evaluation is based on the premise that technology will only be successful if it matches the organizational needs and work practices of the people using the technology. For example, Travers [12] examined the implementation of the same EMR technology in two different pediatric offices (1 and 2). Although both were pediatric offices and had similar needs, the EMR was adopted in office 1 but not in 2. The different outcomes were accounted for not by technology differences but rather by the differences in the work practices and social organization of the two offices. Travers noted that because the staff in office 1 had a cooperative spirit, they were more open to the introduction of new technology than the staff in the less cooperative office 1; office 1 staff also had greater resources to draw upon in adapting to the new system. The socio-technical evaluation of the system highlighted how the success of the technology

depended on the social structure in which it was embedded. Similarly, the implementation of a CPOE system in a pediatric hospital highlights the importance of understanding both the organizational and technical issues surrounding the implementation of a system. In their study, Han et al. [20] found an increased mortality after the implementation of the CPOE system. In reviewing this study, others [21,22] have pointed out the importance of understanding the socio-technical factors that effect the implementation of the system. Otherwise, the consequences of the "misfit" between the system and the work activities can be quite severe.

One of the challenges of evaluating technologies in medical settings is accounting for the strong social practices embedded in these organizations. As stated earlier, when evaluating a system, the focus is usually on the user–system interaction; however, in hospitals, whether a system is accepted or not is greatly affected by the medical staff. They can exert a tremendous amount of influence on whether a clinical system will or will not be successfully utilized. Goddard [23] identified lack of physician support as one reason for their organization's EMR implementation failure. Furthermore, different care providers have different practices that effect how they view and interact with technology. For instance, a physician who needs comprehensive information in the patient's condition has different expectations of the system than a pharmacist who is primarily interested about medication.

Socio-technical evaluation techniques take into account the strongly embedded social practices and allow us to examine how well the technology "fits" with the work activities of nurses, physicians, and other health-care workers.

3. Methods

In this section, we describe the research site, and the data collection and analysis methods that were used in the study.

3.1. Research site

This study took place in the surgical intensive care unit (SICU) of an 952-bed urban teaching hospital [6,8,24]. The SICU provides intensive care-monitoring, invasive and non-invasive, for patients requiring special attention after a surgical procedure. It consists of two 10-bed units each of which has the same technologies, staffing, and physical layout.

Information systems play a crucial role in the SICU. The information systems include web-based systems, digital X-ray machines, and digital monitoring devices. The unit is also equipped with an electronic patient record system CareVue (CV, Philips Medical Systems, Andover, MA), that has been used in a surgical intensive care unit for more than 10 years[1] [26]. Almost all patient information is in CV. Since the patient's bedside monitoring systems are linked to CV, physiological data such as temperature, blood pressure, heart rate, ventilator settings and intake and output fluid volumes are downloaded automatically into the patient's CV record. Most of the data that is not automatically downloaded into CV is entered by nurses. Physicians use CV to monitor the patient's status and to find needed patient information. They also document certain procedures and care activities in CV. Finally, pharmacists are interested in ensuring that the patient is receiving the appropriate medication and that all the information related to the patient's medication is correct. The SICU pharmacist spends several hours each day using CV [8].

3.1.1. SICU team

The primary goal of the SICU team consisting of surgical residents, surgical fellows, surgical attending, pharmacist, and nurses is to stabilize patients as quickly as possible so they can be safely transferred out of the unit. Effective and timely collaboration between physicians, nurses, and pharmacists is critical otherwise the patient will suffer. The importance of this collaboration is highlighted by one of our observations in the unit. In this observed example, a nurse failed to notify the physician that the patient's sodium was rising to dangerous levels. If the physician had been notified quickly, he or she would have been able to give the patient medication to lower the sodium. However, the physician only found out about the sodium levels six hours later, by which time the patient's condition had deteriorated so far that the physician had to intubate the patient to protect the airway. As the example highlights, team members work under constant time pressure that can affect patient care. Therefore, on a daily basis, the physicians, nurses, and pharmacists must collaborate to ensure appropriate patient care.

3.2. Data collection

Qualitative methods are the leading technique for investigating organizational and technological settings in research on collaboration (e.g. [27–29]). In healthcare, these methods have also been widely used to study technology use in collaborative teams [8,30,31]. Qualitative methods focus on observing work environments, artifacts and human interaction to form an understanding of the culture

[1] We recognize that work activities have likely evolved in the 10 years that CV has been implemented. Our goal was to evaluate the features the current system that support collaboration. As with any software system, functionality was not static; it evolved over time. Our approach to evaluating CV in-situ years after its first implementation has been utilized in other studies [25].

of a given technology setting in order to accurately evaluate the system.

In this study, we collected data through observing the work activities of the SICU patient care team and their interactions with CV over a seven month period. During the observations, the first author "shadowed" various individual team members (e.g., physicians, nurses, pharmacist) as they worked. We also shadowed the patient care team as a whole during activities when the team was working together. In addition to the observations, we also conducted more than thirty semi-structured formal interviews which were taped and transcribed. The goals of the interviews were to gain insight into how the team members viewed collaboration in the unit and how they interacted with CV. We also collected and analyzed internal communications, including written policies, procedures, and meeting notes to help us better understand the context of system use. This study was approved by the hospital's Institutional Review Board.

Using ethnographic techniques such as observations, interviews, and artifact collection, researchers have examined a wide variety of social phenomenon *in situ* [32,33]. Phenomena that are most amenable to qualitative research are those that have multifaceted interdependencies that make it difficult to separate the independent and dependent variables. This is especially true in complex settings such as critical care environments where technical, organizational, and social factors intersect (e.g., [34,35]). Data collection techniques provide the tools to gather rich, informative data. However, that data is meaningless unless it is appropriately analyzed. Consequently, the data were analyzed using grounded theory [36].

3.3. Data analysis: grounded theory

Qualitative data is characteristically text-based and voluminous. Transcripts from interviews and notes from observations of a modest study often constitute hundreds of pages of text. The question become, how does one distill meaningful patterns, or theories, from this unstructured body of text? The evaluator does not distill the data; instead he creates and distills analytical categories that describe meaningful uniformities in the data. Theories about the data emerge through an iterative process of comparing and delimiting categories [36,37]. This approach to data analysis is known as *grounded theory*. Applied to information systems in healthcare, grounded theory dictates that the abstract principles formulated to describe a healthcare setting must be grounded in the data and thus must be the product of inductive rather than deductive reasoning. A complete discussion of grounded theory is beyond the scope of this paper, yet an understanding of the philosophy and techniques are warranted.

The ethnographic approach to the analysis of qualitative data involves reviewing the data and creating a classification scheme to describe, i.e. *code*, all relevant observations. An evaluator can generate innumerable descriptive categories to code the data. How does one know when the data coding is finished? Glaser and Strauss [37] provide these two heuristics: *parsimony* and *scope*. The evaluator achieves parsimony of categories through careful comparison of each category to all others to verify that each category is unique. The evaluator achieves parsimony of theory through integrating categories into cohesive conceptual clusters. Integrating categories is a natural byproduct of the constant comparison of categories. The evaluator achieves scope when she delineates the boundaries of the categories (e.g., what the category does and does not apply to).

For example, in analyzing interviews with patient care team members, the data may reveal that both physicians and nurses need to track the administration of medication. When the data documents a nurse or physician making a mental note of the next time a particular medication must be administered, this might be categorized as "awareness of medication administration schedule." Yet, when the data documents a physician scanning records for the frequency and synchronicity of administration of multiple medications to assess the possibility of a drug interaction, this might be compared and then integrated with the "schedule" category and labeled "awareness of co-administration of medications." Various additional variables about medication administration, such as the route a nurse must use to deliver the drug or the physician's personal preference for one particular drug over another may be contained in the data that are not categorized. They are not categorized to maintain parsimony of the categories and to focus the analysis on the awareness of medication administration schedule rather than execution of medication administration (e.g. route) or medication preferences.

By constraining the scope of the analysis in this manner the evaluator may theorize about the effect of various EMR interfaces on collaboration—in our example, the data would reveal that an interface that provides a separate administration schedule for each drug may be sufficient for the nurse but may be entirely inappropriate for the physician. Thus, the researcher's theories about the effectiveness of an EMR interface emerge through the parsimonious use of descriptive categories, through the integration of categories and by scoping the analysis to observations that pertain to information awareness.

4. Results

The results of our data collection and analysis highlighted the highly collaborative nature of work in the SICU and the role that CV played in supporting team member collaboration during these activities.

4.1. Important collaborative activities in the sicu

Through the data analysis, we identified two important collaborative activities in the SICU: morning rounds and medical administration.

4.1.1. Morning rounds

SICU morning rounds play an important role in the unit's patient care process. The goal of morning rounds is to discuss and decide upon a plan of care for that day for each patient. During morning rounds, the SICU team visits each patient. The team begins by viewing X-rays of all the SICU patients. After examining the X-rays, the team "rounds" on each patient. Each of the three residents is responsible for a certain number of patients in the unit. During rounds, the residents "present" their patients to the team. As a resident outlines the patient's current condition, vitals and other information, the fellow and other team members view the patient's record on the CV workstation. They do this both to verify the resident's information and to gather other pertinent information. As one fellow stated, "It is much easier for me to find the information in the system than to wait for them to give it to me." After the resident presents, the fellow examines the patient. The team then discusses the patient's condition and decides on the plan of care for the day. After all the decisions are made, a resident writes a progress note in the patient's CV record.

4.1.2. Medication administration

Ordering and administering medication requires collaboration between physicians, nurses, and pharmacists. In routine situations, most surgeons use a standard set of drugs. However, for complex cases, nurses and pharmacists often provide information that help physicians tailor the medication prescription. Since nurses are constantly by the bedside, they can inform physicians about the patient's physical and mental state. This information can help physicians to decide whether a current drug and dosage are appropriate. If physicians need to prescribe a drug they are not familiar with for a particular problem, pharmacists can provide a list of appropriate medications.

Nurses must collaborate directly with both physicians and pharmacists. When ordered to give an unusual drug, nurses commonly ask the physician why it is being given, especially when the drug causes discomfort or pain to the patient. Most physicians want the nurse to understand the plan of care and will answer such questions readily. The nurses also ask the pharmacist questions concerning the medication and dosage administration. For certain kinds of drugs, such as pain relievers, it is the nurse who observes the patient's response most directly, and whose opinion is usually given high regard by physicians for subsequent pain medication orders.

4.2. CV: supporting collaboration

During morning rounds and medication administration, SICU team members must continuously interact with each other in order to provide appropriate patient care. CV plays an important role in supporting this collaboration amongst team members. In the following section, we describe how CV supports collaboration during the medication administration process.

One important way that CV supports collaboration amongst team members is by providing "awareness". Dourish and Bellotti [38] define awareness as "the understanding of the activities of others which provides a context for your own activity." Individuals can more efficiently coordinate their work if they know about one another's activities. Bricon-Souf and colleagues [39] argue that one way to support successful collaboration is to share information about users' work activities. An EMR can provide users with this awareness, if it is designed to incorporate:

- data concerning others' work activities
- data concerning an individual's own work activities

CV's presentation of medication information supports this awareness. All healthcare providers need information about the patient's medication; however, the exact information they need varies with their roles. CV provides a different view of the same data to different team members (Fig. 1). These customized views of shared information allow team members to remain aware of what other team members are doing in the medication process. Physicians (Fig. 1a) can see what medications have been administered and are scheduled to be administered by the nurse. Since physicians need to quickly survey the status of the treatment, the Medication Flowsheet provides them with quick information about the nurses' past and future work actions regarding patient medication. If physicians have any questions about these actions, they can look elsewhere in CV or contact the patient's nurse. Nurses and pharmacists use a different visual interface, the Medication Administration Record (MAR) (Fig. 1b). The MAR provides additional details about each drug and keeps nurses and pharmacists aware of each other's activities regarding the medications. When a pharmacist approves each medication, he adds an electronic signature to the MAR that is visible to the nurse. Thus, the nurse is aware that the pharmacist has checked the drug for appropriateness, route, and dosage. To administer medications effectively and on-time, nurses use yet another "view" of the MAR, the Medication Worklist (Fig. 1c). The Worklist provides a time-ordered list of the medications, dosages, and administration times for all drugs due to be administered on the current nursing shift. The Worklist allows nurses to know what actions the other team members expect from them in the near future. For convenience, nurses can chart drugs as "given" or "held" directly on the Worklist. Such information instantly appears in the other members' views. CV's ability to transform information into different views that are understandable to each member helps the member remain constantly aware of each other's activities.

Critical care systems are not simply information repositories of patient data but rather are an integral part of the collaboration amongst healthcare team members. The EMR kept team members informed about each other's

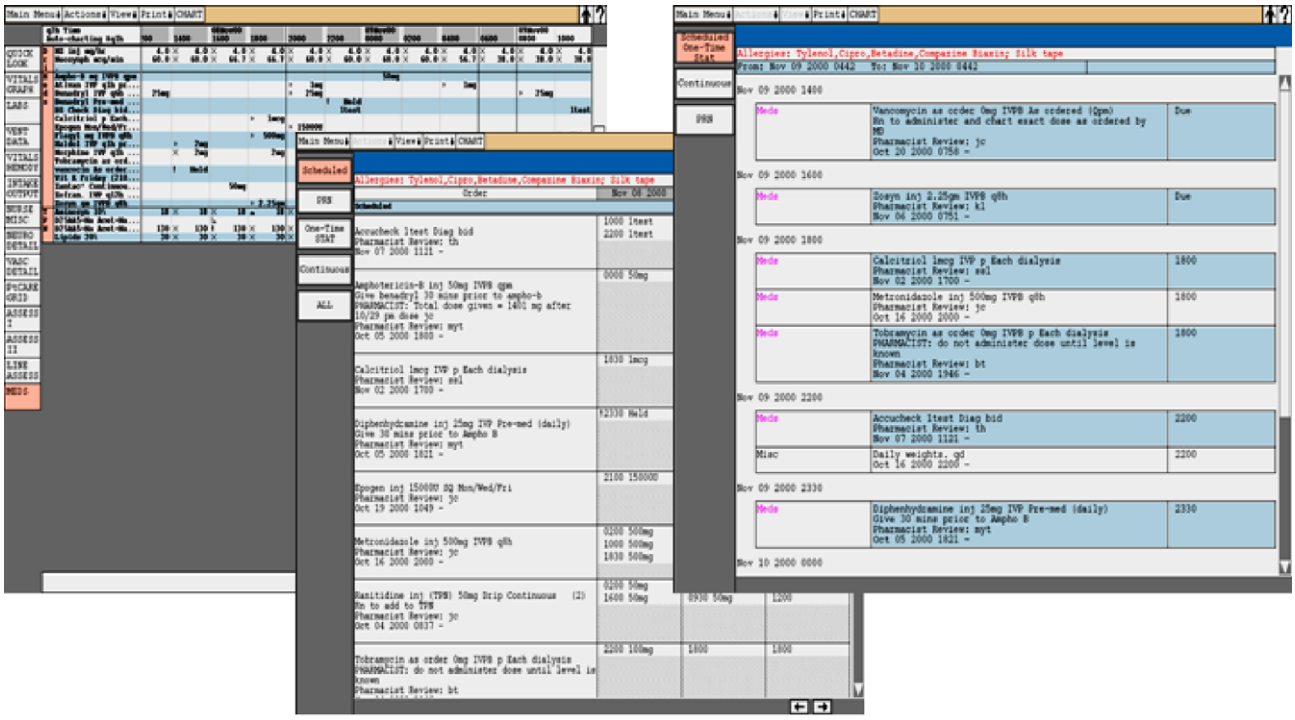

Fig. 1. (a) Physicians use the medication section of the CV Flowsheet to check on patient medications. It provides them with the dosage and administration time. (b) Nurses and pharmacists use the Medication Administration Record (MAR) to provide them with the more detailed information on each medication. (c) Nurses also use the nursing Medication Worklist to keep track of their work activities. It lists the medications for a patient and when they need to be given.

activities allowing them to coordinate their work more effectively during activities such as medication administration. In the next section, we discuss some of the collaborative features that critical care systems need to support and methods that we can use to evaluate these features.

5. Discussion

We would now like to turn our attention to discussing awareness in greater detail and also some recommendations for evaluating how well a system supports collaboration. We provide examples of questions that an evaluator can ask during the evaluation process. These questions were developed based on the lessons we have learned from this and other studies. Although our focus is on evaluation, these same questions can also be asked by system designers to insure that the system appropriately support collaboration.

5.1. Awareness

Members of work teams must share detailed information about their activities and knowledge with each other in order to coordinate their work. Often, awareness is achieved through peripherally monitoring conversations or behaviors of others in collocated workspaces; for example air traffic controllers routinely listen in on the pilot-controller conversations of their teammates in the control tower [27]. On first examination, peripheral auditory monitoring may remain undetected by the evaluator—since it is peripheral and auditory—and it may even seem inconsequential. Yet consider the consequences of implementing an information system that converts conversations in an air traffic control tower from a verbal format easily monitored by all occupants of the tower to a textual format. According to data from ethnographic studies of air traffic controllers, doing so would likely slow the detection of incidents when conflicting flight instructions are given to pilots [27].

Similarly, shared awareness among members of patient care teams is vital to maintaining high quality care [40]. Patients suffer when awareness breaks down. In an earlier section, we described the incident of patient requiring intubation because the nurse failed to notify the physician of the rising sodium levels. If the physician had been alerted quickly—i.e. if there were a shared awareness among the nurse and physician of this condition—the physician could have taken less drastic measures. Furthermore, shared awareness about the time and route a medication is administered is crucial to delivering quality patient care.

Thus, when evaluating critical care systems, evaluators must carefully probe issues of awareness among team members. Some of the evaluation questions may include: How is information about a patient (vital statistics, medi-

cation administration, patient complaints, history, etc.) formally documented in the system? How is this information formally shared among members of the team (consider how it is verbally shared as well as how and when it is printed from the system)? How is this information informally shared: via impromptu conversation, marginalia in written records, special numeric codes sent via numeric pagers, etc? To what extent does the system accommodate informal observations and annotations? For what periods of time do different kinds of information remain relevant? To what extent does the credibility of the information provider affect the way information is documented and used? What happens when awareness breaks down? How does the information system under evaluation help or hinder information sharing?

5.2. Recommendations for improving evaluation of collaborative critical care systems

When evaluating critical care systems, evaluators should also pay particular attention to three issues that effect how well a system supports collaboration. These issues include *multiple perspectives on information*, *workflow dependencies*, and *context*.

5.2.1. Identifying multiple perspectives on information

Evaluating information systems in a collaborative setting is often difficult because of the multiple perspectives present in a team. For instance, in a study of information needs, researchers examined how each team member brought different backgrounds, perspectives, and skills to a multidisciplinary team [3]. These different skills and perspectives had implications for how the information resources were used in the unit. Therefore, to understand how a system is used in a particular setting, we need to examine how different members utilize the system and to evaluate it from as many different perspectives on the team as possible.

The discussion of CV's Flowsheet provides a nice example of multiple perspectives on information [8]. Recall that in CV, physicians can see not only nurses' future medication administration activities but also past medication administration. This view fits their interest in knowing not only what the patient is going to get but also what the patient has already been given. Nurses are most interested in seeing a time-ordered list of the medications, dosages, and administration times for all drugs due to be administered during their current shift. These two different views provide the team members with different information required to carry out their responsibilities, while preserving the uniformity of the underlying medication data.

When evaluating the appropriateness of a critical care system vis-à-vis multiple perspectives on information, the evaluator might ask the following questions: What are the information needs of each member of the work team? How are these needs similar across the formal work role and how are they unique? What, if any information can be shared in a universal format (by what media, in what level of detail)? What information must be tailored to specific work role and why? What are the consequences of one member of the team viewing, editing or deleting information intended for the other members?

5.2.2. Identifying workflow dependencies

Some degree of workflow dependencies exist in all team work. The factory assembly line is the canonical example of highly interdependent team work. Factory automation is evaluated based on the effectiveness by which it isolates and orders the dependencies between factory workers along an assembly line. The dependencies of a patient care team are less visible due to the intellectual nature of the work but nevertheless they are present. The medication administration process highlights the interdependences that exist among members of a patient care team. Physicians order the medications but do not have the ability to continuously monitor the effects of the medication on the patient. Nurses can monitor the patient but cannot order the medications that are needed by the patient. Finally, pharmacists cannot order the medications nor monitor the patient but have the detailed knowledge of particular medications needed by both physicians and nurses. Therefore, each team member depends on the other members in order to carry out the medication administration process safely and effectively.

An important part of workflow dependencies is coordination. Berg [41] explores some of the ways that health care workers employ the medical record as a coordinating device, using it to communicate directly and indirectly and to ensure that their activities mesh effectively. For instance, the physician writes a patient order in the medical record that is read by the nurse. In turn, the nurses write patient information in the record, which helps physicians decide what to do next for the patient. Without using the patient record to coordinate their activities, physicians and nurses would have difficulty collaborating on patient care issues. Coordination is an important feature of workflow dependencies that is only noticed when it fails [42].

To expose and analyze dependencies and coordination on a patient care team, an evaluator may ask questions regarding how work is ordered, reordered, communicated, delegated and controlled for quality. Questions may include: How is a patient's presenting condition assessed and documented? How is the presenting condition communicated to the team? How is a patient diagnosed? Once a diagnosis is made, how is the plan of care documented and shared with the team? How is the quality of care assessed? When a patient's condition deteriorates, what hastens or hinders a new plan of care from being developed and executed?

5.2.3. Accurately identifying context

When evaluating collaborative features of critical care systems, it is important to understand the *context* in which the technology is utilized [43]. Most evaluations focus only on the interaction between the user and the system; they

tend to ignore the environment around the system. The lack of contextual understanding of the system could lead to inaccurate evaluations of a system. Orlikowski's [35] examination of one organization's adoption of the information sharing tool *Lotus Notes* points to the importance of context. If she had not examined the organizational structure and found that disincentives for information sharing exist, then individuals looking at the low adoption levels of *Lotus Notes* could have blamed the system itself for the failure, not the organizational context. Thus, Orlikowski's examination of the organizational context of the system allowed her to more accurately evaluate the system. Forsythe's comments about context further highlights its importance in evaluation studies. She [44] argues that:

> "The lack of contextual features also raises questions about whether important components of meaning are missing from the analysis."

Without examining the context, researchers would have a difficult time understanding the true reasons for a system's success or failure. Kaplan and Duchon [45] note that "the stripping of context buys 'objectivity' and testability at the cost of a deeper understanding of what actually is occurring." Therefore, removing the context of the system could make it easier to evaluate some aspects of the system. Yet, conversely, it would make it more difficult for researchers to examine issues such as the system's "fit" with its environment when evaluating the system.

Understanding the context of use is an important component to evaluating information technology use in collaborative environment. This requires evaluators to understand the daily work activities in that setting in order to understand how a particular technology will be used by staff in that setting.

5.3. Limitations

It is difficult for a single researcher to capture all the observations in the unit. Therefore, we were concerned that we may miss some important team events or interactions. To address this concern, we planned observations throughout the day to ensure that the researcher was capturing different types of team activities as they normally occurred. The researcher also closely followed the team during morning rounds which was the busiest "team" activity of the day. To further ensure that we captured as much relevant data as possible, we conducted interviews based on our observations. The participants were encouraged to provide more information to help fill in the gaps in our observations or to make our observations clearer. Through these activities, we were able to capture the patient care team member interactions with each other and CV.

6. Conclusion

The work activities in the SICU, like many other critical care environments, are detailed, demanding, time-critical, and highly collaborative. At the center of this work is the patient whose health is dependent on effective coordination between physicians, nurses, pharmacists, and other healthcare providers. In these highly collaborative and information-intensive critical care environments, information and decision support systems play a crucial role in supporting the activities of the various healthcare providers. In our evaluation of a critical care system in the SICU, we used a socio-technical perspective to evaluate the system. We examined not only how the system supports the individual user interacting with a system but also how well it supports the collaboration amongst different healthcare providers. We have also developed questions that evaluators can use when examining the collaborative features of a system from a socio-technical perspective.

Evaluators must understand not only the technical aspects of the system but also the work and interactions of team members who use the system. An effective socio-technical evaluation of a system in a collaborative environment involves examining how well the system support such issues as awareness, multiple perspectives on information, and workflow dependencies. Although a number of different approaches can be used to evaluate the system [14,16,46], we have found that qualitative data collection techniques combined with analysis methods such as grounded theory are extremely useful in gaining insight into the collaborative features of critical care systems [8,47]. Because critical care systems play a crucial role in patient care, we must ensure that they appropriately support healthcare providers in highly collaborative environments.

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